PERFORMANCE OF CONCRETE WITH UNCRUSHED PALM OIL SHELL AS COARSE AGGREGATE

TAI KAH MON

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To My Beloved Family and Friends

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ABSTRACT

Malaysia is one of the largest producers of palm oil, contributing about 21 million tons of oil palm products in the export sector. During the process in extracting oil palm, million tons of palm oil shells (POS) as solid wastes were generated. The natural resources of coarse aggregate may be depleted in some day, and the POS as wastes can cause the pollution. In this study, uncrushed POS as aggregate replacement in concrete was studied to determine its performances. A total of 54 concrete cubes and prisms were cast and tested. The workability, apparent dry-density, compressive strength, flexural strength of POS concrete was determined. The findings show that the compressive strength and density of POS concrete was lower than the normal weight concrete. Only the full replacement of the POS concrete was considered as lightweight concrete as the density was lower than 2000 kg/m^3. Besides, a total of 4 under-reinforced concrete beams were cast with the dimensions of 125 x 150 x 1600 mm, and tested to failure under four-point loading. The behaviour of the beams were studied through their load-deflection characteristic upon loading, cracking history, and mode of failure. From the result, the flexural behaviour of POS concrete beam was almost same with the normal weight concrete. The cracking pattern of the POS concrete beam was comparable with the control beam. However, the flexural strength of the POS concrete beam was lower compared with the control beam due to the weak bonding of the POS aggregates and cement paste. Overall results indicate that the POS concrete have a sufficient compressive strength that required by the ASTM C330 for lightweight structural concrete and can be used for lightweight partition in order to reduce the member selfweight.

ABSTRAK

Malaysia merupakan salah satu pengeluar minyak kelapa sawit yang terbesar, iaitu menyumbang kira-kira 21 juta tan minyak kelapa sawit dalam sektor eksport. Semasa pemprosesan minyak kelapa sawit, berjuta-juta tan tempurung kelapa sawit akan dihasilkan sebagai sisa pepejal. Sumber-sumber asli bagi agregat boleh habis pada suatu hari nanti dan tempurung kelapa sawit (POS) sebagai bahan buangan boleh menyebabkan pencemaran. Dalam kajian ini, "uncrushed POS" sebagai pengganti agregat dalam konkrit dikaji untuk menentukan prestasinya. Sebanyak 54 kiub dan prisma konkrit telah dibuat dan diuji. Kebolehkerjaan, ketumpatan kering, kekuatan mampatan, kekuatan lenturan konkrit POS telah ditentukan. Hasil kajian menunjukkan bahawa kekuatan mampatan dan ketumpatan konkrit POS adalah lebih rendah daripada konkrit biasa. Hanya penggantian penuh konkrit POS boleh dianggapkan sebagai konkrit ringan kerana ketumpatannya adalah lebih rendah daripada 2000 kg/m^3. Di samping itu, sebanyak 4 rasuk konkrit bertetulang telah dibuat dengan dimensi 125 x 150 x 1600 mm, dan diuji di bawah ujian beban empat titik sehingga gagal. Kelakunan rasuk dikaji melalui ciri-ciri seperti beban-pesongan apabila dibebankan, corak keretakkan, dan bentuk kegagalan. Dari hasil kajian, kelakunan lenturan rasuk konkrit POS adalah hampir sama dengan konkrit kawalan. Corak keretakan rasuk konkrit POS adalah setanding dengan rasuk kawalan. Walaubagaimanapun, beban muktamad lenturan rasuk konkrit POS adalah lebih rendah berbanding dengan rasuk kawalan disebabkan ikatan yang lemah antara POS agregat dan simen. Hasil kajian keseluruhannya menunjukkan bahawa konkrit POS mempunyai kekuatan mampatan yang cukup seperti yang dikehendaki oleh ASTM C330 untuk konkrit ringan dan boleh digunakan sebagai "partition" untuk mengurangkan berat badan struktur.

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CHAPTER I

INTRODUCTION

1.1 Background of Palm Oil Shell Concrete

Concrete is composite materials that contain cement that acts as binders and other cementitious material, coarse aggregate such as the granite stone, fine aggregate such as the sand and some more may contain the chemical admixtures such as water reducing chemicals.

However, palm oil shell concrete is different compared with the conventional concrete in terms of the constituents' materials. Palm oil shell concrete is composite materials that contain cement as the binder, cementitious material, fine aggregate such as sand, but the coarse aggregate replaced by the palm oil shell. Hence, the palm oil shells acts as coarse aggregate in this type of concrete.

Malaysia is well known for the palm oil industries and is one of the largest palm oil producers and exporter in the world [1]. In 2009, total productions of the

oil palms are about 29 million tons, whereas in the export sector, it contributes about 21 million tons of oil palm products [2]. Although the palm oil industries can give economical advantages to the country, but excessive waste products are generated and left to rot in large amounts and sometimes disposed through incineration which can cause pollution to the environment.

Since the palm oil shell is a byproduct during the extraction process of oil palm fruitlets, hence, it can be categorized as organic materials that can be deteriorated with the time. However, these oil palm shells will not contaminate or leach to produce toxic substance once it bound inside the concrete [3].

The palm oil shells obtained can be crushed type or uncrushed type. The crushed palm oil shells have irregular shapes and different sizes of shells, different thickness of the shell and having low density compared with the conventional aggregate. Whereas for the uncrushed palm oil shell, the shapes are spherical and it can be smooth or rough depend on the extraction process.

Besides, the properties of the palm oil shell are very different from the conventional aggregates. These shells have high porosity compared to conventional aggregates, hence it will have a low bulk density and having a high water absorption capacity [4].

The low bulk density of the palm oil shells can produce lightweight hardened concrete. These lightweight concretes are very useful in construction industry since the lightweight concrete can reduce the self weight of structural members. Thus, it can reduce the dead load of the structure and reduce the use of reinforcement steel. This results the overall cost reduction in construction industries [1].

In addition, palm oil shells do not need any chemical pretreatment compared with the artificially produced lightweight aggregate before it is used [5]. The palm oil shell concrete can easily attain the strength of more than 17 MPa which is a requirement of structural lightweight concrete as ASTM C330 [6].

Palm oil shells can be used to as the road base material especially in palm oil estate to reduce the cost in buying the granite stone to construct crusher run. Besides, palm oil shell concrete can be used for the construction of low cost houses. The oil palm shell used to make the hollow blocks for the walls and the oil palm shell concrete used to construct the footings, lintels and beams. These has been done in Universiti Malaysia Sabah (UMS) in 2003 and these structures are still performing well and has no structural problems [7].

1.2 Problem Statement

With the continual use of natural resources aggregate in the production of concrete which consume a lot of it, the resources will be depleted someday. The prices of the conventional aggregate begin to increase due to the limited resources and the process involved in crushing the aggregate. This will create an economy chain that will cause the prices of housing increases, and not only the housing, other products' prices will also increase due to the indirect effects. In ensuring the availability of resources in future, steps must be taken to conserve the non-renewable resources and energy.

In other industries, especially the agro-based industries, abundant wastes are produced and treated improper way will cause the pollution to the environment [1]. The untreated waste can pollute the land, water and air via leaching, dusting and volatilization. Legislatives are needed to be determined in order to control and

minimized the pollutants released to other areas [6]. But if these wastes are investigated and studied, these wastes have a potential to be used as construction material.

Recycling and utilization of agricultural waste and industrial by-products are very beneficial to our environment and industry. Increasing of the wastes products, resources preservation and material cost has result in the utilization of solid wastes. Material recovery from the agricultural wastes and industrial waste into reusable materials not only can protect the environment, but also can preserve the natural resources since the natural resources are limited [6].

Malaysia, the second largest oil palms producer and exporter in the world, produce more than 4 million tons of palm oil shells during the process of palm oil extraction annually [5]. These oil palm shells, as a waste product of the extraction process, being left at the mill to rot in a large amount and some of the wastes are being disposed through incineration. This will cause pollution to the environment indirectly [5].

As the natural resources are being depleted and the pollution cause by the palm oil shell are getting serious, this situation justify the investigation and studies need to be done on the suitability of palm oil shell as a replacement of conventional aggregate in concrete. Hence, this study is carried out to investigate the performance of concrete with uncrushed palm oil shell as aggregate.

1.3 Objectives of Study

The purpose of this study is to investigate the performance of concrete with uncrushed palm oil shells (UCPOS) as aggregates. Objectives of this study are as follow.

i.) To study the workability of the fresh UCPOS concrete

ii.) To study the dry-density of UCPOS concrete

iii.) To study the compressive strength and flexural strength of the UCPOS concrete with different percentage of UCPOS replacement.

iv.) To study the flexural behavior of UCPOS concrete beam.

1.4 Scope of Study

The scope of this research will cover the application of the uncrushed palm oil shells (UCPOS) as aggregates, where the conventional aggregates in normal weight concrete will be replaced by the palm oil shells by percentage. Tests will be carried out to determine the performance of palm oil shell concrete. Data to be collected include:

i.) Workability of the fresh palm oil shell concrete

ii.) Compressive strength and flexural strength of palm oil shell concrete with different percentage of UCPOS replacement

iii.) Flexural strength of the palm oil shell concrete beam

iv.) Load-deflection characteristics of the UCPOS concrete beam

v.) Mode of structural failure of UCPOS concrete beam